



**INFLUENCE OF GOLD SILVER PLATING THICKNESS ON
PALLADIUM COATED COPPER WIRE ON STITCH
BONDING**

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**MASTER OF SCIENCE
IN MANUFACTURING ENGINEERING**

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Faculty of Manufacturing Engineering

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**A thesis submitted
in fulfillment of the requirements for the degree of Master of Science
in Manufacturing Engineering**

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2016

DECLARATION

I declare that this thesis entitled “Influence of Gold Silver Plating Thickness on Palladium Coated Copper Wire on Stitch Bonding” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name :

Date :

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Manufacturing Engineering.

Signature :

Name :

Date :

DEDICATION

To my beloved family, lecturers and friends.

ABSTRACT

Low cost, high reliable and robust semiconductor packages are required in order for semiconductor manufacturer to stay competitive in the industry. This requires a stable manufacturing process that able to maintain high production yield, reduce customer reject and scrap cost. Currently, combination of Ni/Pd/AuAg preplated Cu alloy leadframe and Palladium coated copper (PCC) wire is used in the wire bonding process of semiconductor package due to its robustness package performances. Nevertheless, studies on the influence of plating layer thickness of roughened preplated leadframe to the stitch bonding strength of the PCC wire is still lacking and not well understood. The purpose of the current study is to investigate the effect of thickness of AuAg plating (i.e. the top plating layer) of the preplated leadframe on the PCC stitch wire bonding. Regression and ANOVA analysis showed AuAg plating's thickness of preplated leadframe was the predominant factor on the stitch bonding strength of PCC wire bonding. The bonding force is the second dominant force, followed by the bonding time. However, the DoE results shows AuAg plating thickness has no significant influence (P value >0.05) on the frequency of machine stoppages (i.e. caused by 'no tail' and 'nonstick on lead' failure on PCC wire stitch bond). Stitch pull strength of PCC wire bonding on the preplated leadframe increased from 10.10 gram-force to 11.20 gram-force, when the AuAg plating's thickness increased from 7.0 to 35.2 nm. Cross-sectional view micrographs of all the stitch bond samples showed failure mode at stitch bond heel, implied the mechanical failure caused by stitch pull test, may be initiated by crack located at the mechanical deformed wire regions (i.e. stitch bond heel). Lower deformation on bond heel observed with thicker AuAg thickness. This is verified by stitch bond thickness data that exhibited thicker stitch bond heel thicknesses when stitch bonding was performed on leadframe with larger AuAg thickness. Stitch remains' length increases with larger AuAg thickness because the resulted thicker stitch heels able to withstand higher stitch pull strength, thus elongated further before break up. Thus, both design of experiments and microstructure analysis results supported the stitch pull strength results as function of AuAg plating thickness. Stitch bonding between PCC wire and leadframe was formed through interdiffusion involving Pd species from PCC wire and Au and Ag species from AuAg plating at the bonding interface. Bonded sample with larger AuAg plating thickness exhibited wider interdiffusion zone, thus further strengthened the stitch bond shear strength. This later prevents shear failure at stitch bond interface during stitch pull test. Higher stitch bond strength further strengthens the package reliability. Thus, it enables semiconductor package application extend into automotive industry like power, safety and engine control applications.

ABSTRAK

Pakej semikonduktor yang berkos rendah, diyakini dan tahan lasak adalah diperlukan agar pengeluar dan pembuat semikonduktor kekal bersaing di dalam industri ini. Process pembuatan yang stabil serta berupaya mengekalkan prestasi pengeluaran yang bermutu tinggi amat diperlukan bagi mengurangkan barangan ditolak pelanggan dan kos sisa. Kini, kombinasi diantara 'leadframe' bersadur Ni/Pd/AuAg dan wayar Cu bersadur Pd (PCC) digunakan di dalam process jalinan antara wayar dan permukaan 'leadframe'. Ini disebabkan prestasi dan keupayaan tahan lasak pakej. Walaubagaimanapun, kajian ke atas kesan ketebalan lapisan saduran bagi 'leadframe' pra-sadur dan permukaan 'leadframe' yang dikasarkan, berserta kekuatan lekatan jalinan wayar PCC masih lagi berkurangan dan tidak difahami sepenuhnya. Tujuan kajian ini ialah menyiasat kesan ketebalan saduran AuAg (lapisan teratas saduran) pada 'leadframe' pra-sadur keatas lekatan jalinan wayar PCC. Keputusan analisis Regresi dan ANOVA menunjukkan ketebalan saduran AuAg bagi 'leadframe' pra-sadur adalah faktor utama kepada kekuatan lekatan jalinan wayar PCC. Daya lekatan adalah faktor dominasi kedua, diikuti dengan masa lekatan. Menurut keputusan DOE yang dijalankan, pengaruh ketebalan saduran AuAg boleh diabaikan dan tidak memudaratkan keatas kekerapan penghentian mesin (i.e disebabkan oleh 'no tail' dan 'nonstick on lead' pada lekatan jalinan wayar PCC). Berdasarkan ujian tarikan keatas lekatan wayar, Kekuatan lekatan jalinan wayar PCC keatas 'leadframe' pra-sadur, meningkat dari 10.10 gram-daya ke 11.20 gram-daya dan berkadar langsung dengan ketebalan lapisan AuAg yang meningkat dari 7.0 nm ke 35.2nm. Pandangan keratan rentas micrograf bagi semua sampel lekatan jahitan menunjukkan mod kegagalan pada tumit. Lapisan AuAg yang tebal memberikan kesan kusyen yang lebih besar terhadap penyahbentukan tumit dawai semasa process ikatan jahitan. Ini disahkan oleh data jahitan ikatan yang menunjukkan tumit bon jahitan yang tebal dengan ketebalan AuAg yang lebih tinggi. Baki ikatan jahitan didapati juga meningkat dengan ketebalan AuAg yang semakin tinggi. Ini adalah kerana ketebalan ikatan jahitan tumit yang tinggi mampu menampung daya tarikan ikatan jahitan yang lebih kuat, menyebabkan tumit ikatan jahitan terus memanjang sebelum putus. Oleh itu, kedua-dua keputusan eksperimen dan analisis mikrostruktur menyokong keputusan kekuatan tarikan ikatan jahitan sebagai fungsi ketebalan saduran AuAg. Ikatan jahitan antara wayar PCC dan 'leadframe' dibentuk melalui interdiffusion yang melibatkan spesies Pd dari wayar PCC dan Au serta Ag spesies dari penyaduran AuAg atas 'leadframe'. Sampel ikatan dengan lapisan AuAg yang lebih tebal mempamerkan lapisan zon interdiffusion yang lebih luas, seterusnya mengukuhkan lagi kekuatan ikatan jahitan serta mencegah kegagalan ricih semasa ujian tarikan ikatan jahitan. Ikatan jahitan yang tinggi dapat mengukuhkan kebolehppercayaan pakej. Oleh itu, pakej semikonduktor dapat dilanjutkan ke industri automotif seperti aplikasi di kawalan kuasa, keselamatan dan bahagian enjin.

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TABLE OF CONTENTS

	PAGE
DECLARATION	
APPROVAL	
DEDICATION	
ABSTRACT	i
ABSTRAK	ii
ACKNOWLEDGEMENTS	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	vii
LIST OF FIGURES	ix
LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES	xv
LIST OF PUBLICATIONS	xix
CHAPTER	
1. INTRODUCTION	1
1.0 Research Background	1
1.1 Problem Statement	4
1.2 Research Objectives	5
1.3 Hypothesis	5
1.4 Scope of the Research	6
2. LITERATURE REVIEW	7
2.0 Introduction	7
2.1 Semiconductor Packaging Trend: Latest Development	7
2.2 Structures in a Semiconductor Package	9
2.3 Type of Bonding Wire and its Material Properties	10
2.3.1 Coated Copper Wires	13
2.4 Chip Carriers	14
2.4.1 Ni/Pd/Au and Ni/Pd/Au/Ag Plated Leadframe	16
2.4.2 Nickel/Palladium/ Gold Silver alloy (NiPdAuAg) Plated Leadframe	17
2.4.3 Ni/Pd Plated Leadframe	17
2.4.4 Ag Plated Leadframe	17
2.5 Leadframe Surface Properties and its Influence on Wire Bonding	18
2.5.1 Plating Thickness	18
2.5.2 Surface Roughness	19
2.5.3 Hardness	19
2.6 Interconnection Methods	20
2.7 Wire Bonding	23
2.7.1 Ball Bonding	25
2.7.1.1 First Ball Bond	27
2.7.1.2 Second Stitch Bond	27
2.7.2 Wedge Bonding	28

2.8	Parameters influencing Wire Bonding	29
2.8.1	Bonding Wire	29
2.8.2	Bonding Force	30
2.8.3	Ultrasonic Power	30
2.8.4	Bonding Temperature	31
2.8.5	Bonding Time	32
2.8.6	Bonding Gas Environment	32
2.8.7	Capillary Dimension and Surface Finishing	32
2.8.8	Other Bonding Parameters	34
2.8.9	Bonding Surface Cleanliness	34
2.8.10	Plasma Cleaning	35
2.9	Wire Bonding Failures	37
2.9.1	Cratering	37
2.9.2	Broken Stitch	37
2.9.3	Insufficient Tails Length or ‘No Tail’	38
2.9.4	Peeling	38
2.9.5	First and Second Bond ‘Nonsitck’ Defect	39
2.9.6	Intermetallic Compound- Kirkendall Void	39
2.10	Bonding Mechanism of Copper Wire on Preplated Leadframe	40
2.10.1	Metallurgical Systems	42
3.	RESEARCH METHODOLOGY	47
3.0	Research Methodology Overview	47
3.1	Design of Experiment	50
3.1.1	Selection of Key Factors and Level Setting	51
3.1.2	DoE Matrix	53
3.1.3	Regression Analysis	54
3.1.4	Analysis of Variance (ANOVA)	55
3.1.5	Residual Analysis	56
3.2	Fabrication Process of Ni/Pd/AuAg Preplated Cu Alloy Leadframe	57
3.3	Wire Bonding	63
3.4	Characterization	64
3.4.1	Characterization of Palladium Coating of PCC Wire	64
3.4.2	Preplated Leadframe’s Surface Roughness Measurement	64
3.4.3	Stitch Pull Strength Measurement	65
3.4.4	Stitch Bond Failure Mode Examination	66
3.4.5	Stitch Bond Interface Imaging	67
3.4.6	Stitch Bond Interface Elemental Profiling	67
4.	RESULT AND DISCUSSION	68
4.1	Characterizations of Ni/Pd/AuAg Preplated Leadframe and PCC Bonding Wire	68
4.1.1	Surface Roughness of as-recieved Preplated Leadframe	68
4.1.2	Thickness of as-received Preplated Leadframe	74
4.1.3	Palladium’s Thickness in PCC Wire	76
4.2	Design of Experiment: Evaluation of Factors	78

4.2.1	Regression Model for Stitch Pull Strength Data	80
4.2.2	Predicted Response for ‘No Tail’ Failure	82
4.2.3	Regression Analysis	84
4.2.4	Analysis of Variance (ANOVA)	86
4.2.5	Residual Plots	87
4.3	AuAg Thickness Influence to Stitch Pull Strength of PCC Wire on Preplated Leadframe	90
4.3.1	Comparison of Stitch Bonding Strength Trend of Bare Cu Wire and PCC Wire	93
4.4	Stitch Bond Morphological Analysis	95
4.4.1	Stitch Remains of Stitch Pull Failure Mode on different AuAg Thickness Leadframe	98
4.5	Cross Sectional Microstructure of Stitch Bond of PCC Wire on Preplated Leadframe	100
4.5.1	Stitch Bond Heel Thickness	104
4.6	Microstructure of Stitch Bonding Interface	106
4.7	Elemental Profiling of Bonding Interface	110
5.	CONCLUSION AND RECOMMENDATIONS	115
5.1	Conclusion	115
5.2	Recommendation	116
	REFERENCES	117

LIST OF TABLES

TABLE	TITLE	PAGE
2.1	Materials properties of different commonly used bonding wires	11
2.2	Comparison of common chip carriers used in the semiconductor industry	14
2.3	Overview of types of interconnect and comparison	21
2.4	Comparison of different wire bonding technique	23
2.5	Summary table of bonding wire's metallurgical systems	43
3.1	Details of stitch bond sample preparations and characterizations	49
3.2	Plating thicknesses and DoE level setting of Ni/Pd/AuAg preplated Cu alloy leadframe with different AuAg thicknesses	52
3.3	Input factors and level setting focus on the wire bonding parameters	53
3.4	DoE Matrix generated by combination of AuAg thickness, bond force and bonding time factors	54
3.5	Explanation of the term use in statistical software of regression analysis	55
3.6	Term used and its definition in ANOVA analysis results	56

3.7	Plating layers of Ni/Pd/AuAg preplated Cu alloy leadframes and their functions	61
4.1	Regression analysis of average surface roughness of leadframe's lead finger as a function of AuAg thickness	71
4.2	Summary of roughness measurement on different AuAg thickness samples	74
4.3	AuAg thickness data (obtained from Haesung DS using XRF characterization) of leadframe used by the current study	75
4.4	DoE matrix of stitch bonding study of PCC wire on Ni/Pd/AuAg preplated Cu alloy leadframe	79
4.5	Regression analysis results which based on the DOE analysis	85
4.6	Data of stitch pull strength (unit: gf) with different AuAg thicknesses (unit: nm) of roughen preplated leadframes with palladium coated copper wires	92
4.7	Stitch pull strength of bare Cu and and Pd coated Cu (PCC) wire bonding as function of leadframes' AuAg plating thickness	94

LIST OF FIGURES

FIGURE	TITLE	PAGE
1.1	Comparison of schematic structure of typical resin-molded semiconductor packages assembled using lead-free Ag-Sn (left) leadframe and Ni-Pd-Au (or Ni-Pd-AuAg) (right) preplated leadframe	2
1.2	Cross sectional view of Ni-Pd-AuAg preplated leadframe used by the current study (manufactured by Haesung DS Co., previously known as Samsung Techwin Co.)	3
2.1	Worldwide semiconductor market history and forecast from year 1992 to 2017	8
2.2	Average electronics contents per car trend and forecast from year 2006- 2020	9
2.3	Schematic structure of a typical semiconductor package	10
2.4	An example of a chip carrier design	15
2.5	Schematic diagrams of three types of interconnects	21
2.6	Microstructural comparison of ball and wedge bond	25
2.7	SEM images of first ball bond (left) and second stitch bond (right)	25
2.8	Overview of ball bonding cycle	27

2.9	Overview of wedge bonding cycles	29
2.10	Capillary dimension overview and formation of stitch bond	33
3.1	Overview of research methodology plan	48
3.2	Flow chart of DoE	51
3.3	QFP-type AuAg/Pd/Ni preplated Cu alloy leadframe	57
3.4	Flow of preplated leadframe fabrication process	58
3.5	Process flow of electroplating of Ni/Pd/AuAg plated Cu alloy leadframes	59
3.6	Rough surface of as-received preplated leadframes from top view using FESEM under magnification of: (a) 2500× and (b) 10000×	60
3.7	FESEM image of as-received roughened preplated leadframes viewed from tilting angle of 45° under magnification of 10,000×	60
3.8	Preplated leadframes structure of Ni/Pd/AuAg build up on top of copper alloy base material	61
3.9	Photograph of Shinkawa wire bonder, model: UTC 3000	63
3.10	SENSOFA 3D Optical profiler	65
3.11	Stitch pull test diagram with pull hook position and pulling direction	66
4.1	Optical image of an unit of surface roughened QFP 176 pin (magnification 8×)	69
4.2	Average roughness (S_a) on die paddle and lead finger of Ni/Pd/AuAg preplated Cu alloy leadframe with different AuAg thicknesses (unit: nm)	70

4.3	3D optical image of surface roughness of leadframe with AuAg thickness of 10.9 nm	72
4.4	3D optical image of surface roughness of leadframes with AuAg thickness of 19.8 nm	73
4.5	3D optical image of surface roughness of leadframes with AuAg thickness of 28.7 nm.	73
4.6	STEM-EDX profiling of cross section of sample 5 (i.e. 35 nm AuAg leadframe)	76
4.7	Scanning electron microscopy image of Palladium coated copper wires. Spectrum 1 and spectrum 2 indicated points taken for Pd thickness measurements	77
4.8	Pd thickness data collected along the circumference of the as-received PCC wire. Dashed horizontal line indicates average Pd thickness value	78
4.9	Response graph of stitch bond strength versus AuAg thickness, bond force and bonding time	80
4.10	Correlation plot of stitch bonding strength versus AuAg thickness	81
4.11	Predicted response graph of 'no tail' failure versus AuAg thickness, bonding force, and bonding time	82
4.12	Correlation plot of 'no tail' count versus bonding force	83
4.13	Contour plot of AuAg thickness and bonding force with predicted stitch bonding strength and 'no tail' failure count	84

4.14	ANOVA data for stitch pull strength data	87
4.15	Analysis of variance (ANOVA) for ‘no tail’ failure	87
4.16	Residual probability plots for stitch bonding strength	88
4.17	Effects pareto indicating significant factors influencing stitch bonding strength (unit: gf)	89
4.18	Residual probability plots for ‘no tail’ failure count	89
4.19	Effects pareto showing bond force as significant factors for ‘no tail’ failure	90
4.20	Stitch pull strength (unit: gf) of PCC wire with different AuAg thicknesses of roughen preplated leadframes	92
4.21	Stitch pull strength (unit: gf) of bare copper wires with different AuAg plating thickness of roughen preplated leadframes	93
4.22	Overview of stitch bond morphology of PCC wire bonding on preplated leadframe of AuAg thickness under high power scope with magnification of 200x with: (a) 7.0 ± 0.2 nm, (b) 10.9 ± 0.3 nm, (c) 19.8 ± 1.0 nm, (d) 28.7 ± 2.8 nm and (e) 35.2 ± 14.9 nm	95
4.23	Stitch formation and measurement definition of stitch length and stitch width	96
4.24	Stitch width measurement versus AuAg thickness	96
4.25	Stitch length measurement with different AuAg thickness	97

4.26	Sample comparison of stitch width and length for different AuAg thickness	97
4.27	Optical images (200× magnification) of stitch pull failure mode of stitch bond on preplated leadframe with AuAg thickness: (a) 7.0 nm, (b) 10.9 nm, (c) 19.8 nm, (d) 28.7 nm, and (e) 35.2 nm	99
4.28	Stitch remain measurement on the stitch bond	100
4.29	Stitch remains measurement with different AuAg thickness	100
4.30	Stitch bond cross section view at respective 1000× and 7000× magnifications for bonded samples with AuAg plating thicknesses of 7.0 nm (a, b), 10.9 nm (c, d), 19.8 nm (e, f), 28.7 nm (g, f) and 35.2 nm (i, j) AuAg thickness samples	101
4.31	Cross section view of stitch bond break at stitch heel in 2000x magnification with different AuAg thickness, (a) 7.0 nm, (b) 10.9 nm, (c) 19.8 nm, (d) 28.7 nm and (e) 35.2 nm	103
4.32	Stitch heel thickness measurement	104
4.33	Stitch bond heel thickness measurement with different AuAg thickness	106
4.34	Stitch bonding cross section image with AuAg thickness (a) 7.0 nm, (b) 10.9 nm, (c) 19.8 nm, (d) 28.7 nm and (e) 35.2 nm taken using STEM	107
4.35	STEM image of stitch bonding interface with different AuAg thickness of (a) 7.0 nm, (b) 10.9 nm, (c) 19.8 nm, (d) 28.7 nm and (e) 35.2 nm	109

4.36	Cross section STEM views of stitch bonding interface on AuAg 7 nm thickness samples and EDX profiling on interface	112
4.37	Cross section STEM views of stitch bonding interface on AuAg 10.9 nm thickness samples and EDX profiling on interface	112
4.38	Cross section STEM view of stitch bonding interface on AuAg 19.8 nm thickness Samples and EDX profiling on interface	113
4.39	Cross section STEM view of stitch bonding interface on AuAg 28.7 nm thickness samples and EDX profiling on interface	113
4.40	Cross section STEM view of stitch bonding interface on AuAg 35.2 nm thickness samples and EDX profiling on interface	114

**LIST OF ABBREVIATIONS,
SYMBOLS AND NOMENCLATURE**

Ag	-	Argentum
Al	-	Aluminium
Ar	-	Argon
Au	-	Aurum
Be	-	Beryllium
BGA	-	Ball grid array
BT	-	Bismaleimide Triazine
CAGR	-	Compound annual growth rate
CN	-	Cyanide
Cr	-	Chromium
CQFP	-	Ceramic quad flat package
CSP	-	Chip scale package
Cu	-	Cuprum
DF	-	Degree of freedom
DIP	-	Dual in line package
DOE	-	Design of experiment
ECU	-	Electronic control unit
EDX	-	Energy dispersion x-ray

EFO	-	Electric flame off
ENEPIG	-	Electroless nickel electroless palladium immersion gold
FAB	-	Free air ball
FCC	-	Face center cubic
Fe	-	Ferum
FESEM	-	Field emission scanning electron microscope
FIB	-	Focus Ion Beam
FR4	-	Flame retardant 4
GAM	-	Brightness value
g/cm^3	-	gram per centimeter cube
gf	-	gram force
GPS	-	Global positioning satellite
H_2	-	Hydrogen
HEPA	-	High efficiency particulate air
IC	-	Integrated circuits
IMC	-	Intermetallic Compound
I/O	-	Input Output
LCD	-	Liquid crystal display
L/min	-	Litre per minute
Low-k	-	Small dielectric constant
MIS	-	Molded interconnect substrate
MPa	-	Mega pascal
ms	-	milisecond
N_2	-	Nitrogen

Ni	-	Nickel
Ni-P	-	Nickel Phosphorus
Ni-Pd-Au	-	Nickel Palladium Aurum
Ni-Pd-AuAg	-	Nickel Palladium Aurum Argentum
nm	-	Nanometer
Ohm.m	-	Resistivity, Ohm meter
Pb	-	Lead, Plumbum
PCB	-	Printed circuit board
PCC	-	Palladium coated copper wire
Pd	-	Palladium
PGA	-	Pin grid array
PLCC	-	Plastic leaded chip carriers
ppm	-	Part per million
Ra	-	Average roughness
RMS	-	Root mean square
QFP	-	Quad flat package
QIL	-	Quad in line
RoHS	-	Restriction of the use of certain hazardous substance in electrical and electronic equipment
SIP	-	Single in line
Sn	-	Stannum, Tin
SOIC	-	Small outline integrated circuit
SS	-	Sum of squares
STEM	-	Scanning transmission electron microscopy

TAB	-	Tape automated bonding
TEM	-	Transmission electron microscopy
TV	-	Television
UV	-	Ultraviolet
vol%	-	Volume percentage
XRF	-	X-ray fluorescence spectroscopy
W	-	Watt
WEEE	-	Waste electrical and electronic equipment.
WLP	-	Wafer level package
W/mK	-	Watt per meter kelvin
wt%	-	Weight percentage
Zn	-	Zinc
°C	-	Degree Celsius
µm	-	micro meter
lb./in. ²	-	pound per square inch,